Corrosion Deposits

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Project Objective

Determine the composition of solids collected from DW DS where measurable amounts of arsenic in the finished water

- **pipe sections (corrosion products, deposits, etc.,)**
- **fire hydrant flush (loose particles, corrosion products, etc.)**

Fire Hydrant Flush

Pipe Material

Took what we could get when we could get it.

Any material was acceptable (PVC, AC, cast iron, copper, etc..)

Scrape (layering if possible), grind

PVC pipe

Iron pipe

Pipe Scale Cross Section

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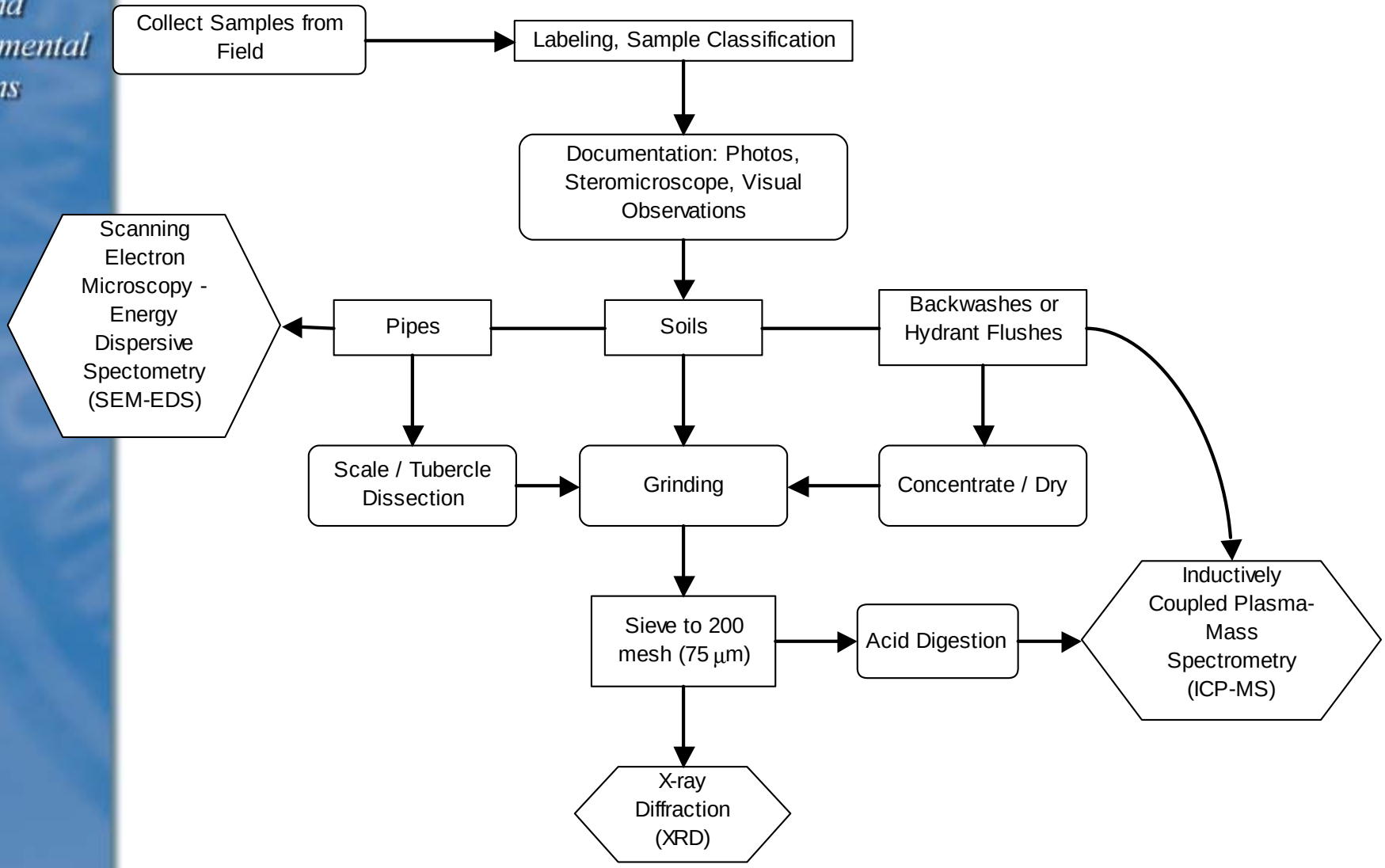
Sample Preparation



Solids Analysis

Acid digestion/ICP-MS (Battelle)

- **Ca, Mn, Fe, Mg, P, Si, As**
- **Units**

XRF (Univ. of Cincinnati Geology Dept.)

- **Cl, S, Ba, Ca, Mn, Mg**

XRD

- **Mineral phases**

Electron mircoprobe-WDS (Battelle)

- **Quantitative elemental mapping**

SEM-Wavelength dispersive spectrometer-imaging and elemental mapping

Analysis Techniques

X-ray Diffraction

- Identification of crystalline minerals
- Crystal size approximation

SEM - Energy Dispersive Spectrometry

- High magnification micrographs
- Elemental composition and mapping

Analysis Techniques

X-ray Photaelectron Spectrometry

Determines oxidation state, bonding energy, bond type, and chemical composition

Electron Microprobe

Determines the chemical composition of very small samples, and produce high resolution elemental maps

Analysis Techniques

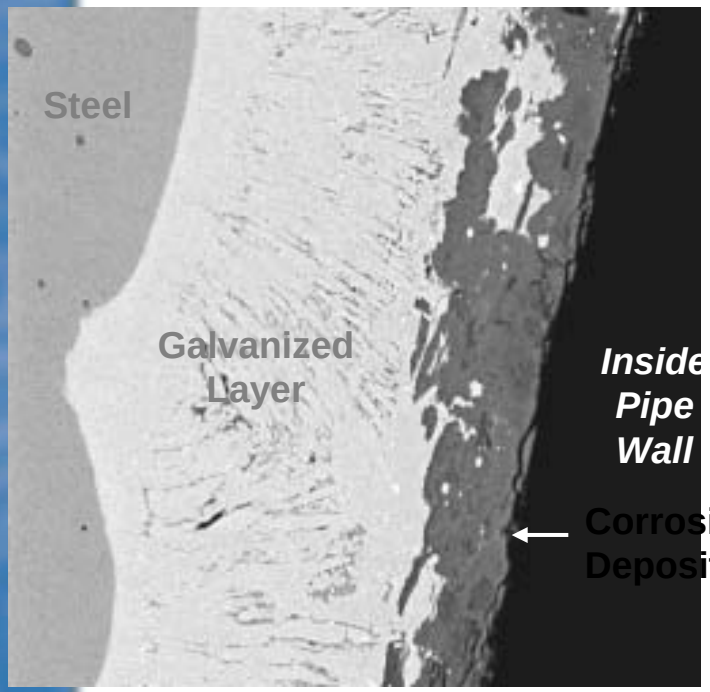
Acid Digestion and ICP – MS

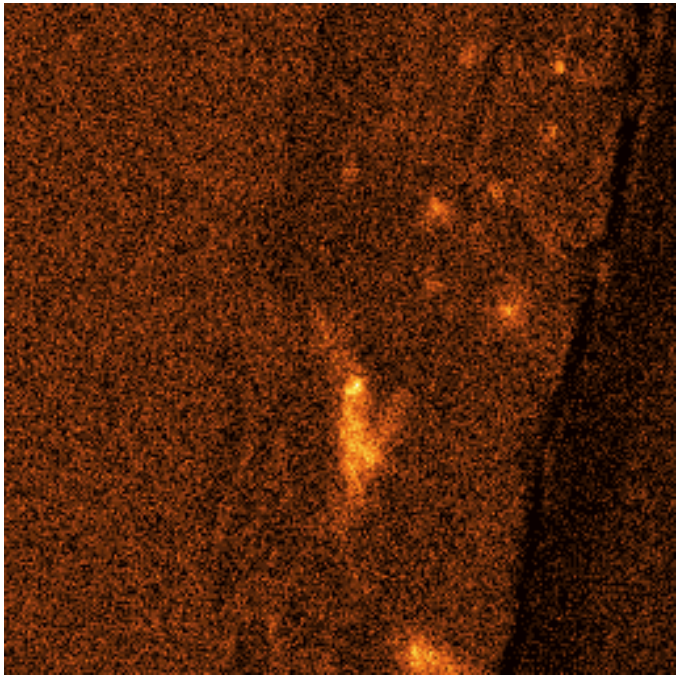
- Provides quantitative elemental composition of solid samples
- This technique is destructive

X-Ray Florescence

Provides semi-quantitative elemental composition without destroying the sample.

Elemental Mapping- Microprobe-WDS analysis





Arsenic distribution

Effects of Iron Scales and Iron Release

- Particle formation
- Discolored water
- Staining of fixtures, clothing
- Metallic tasting water
- Flow restriction
- Oxidant demand
- Biofilm

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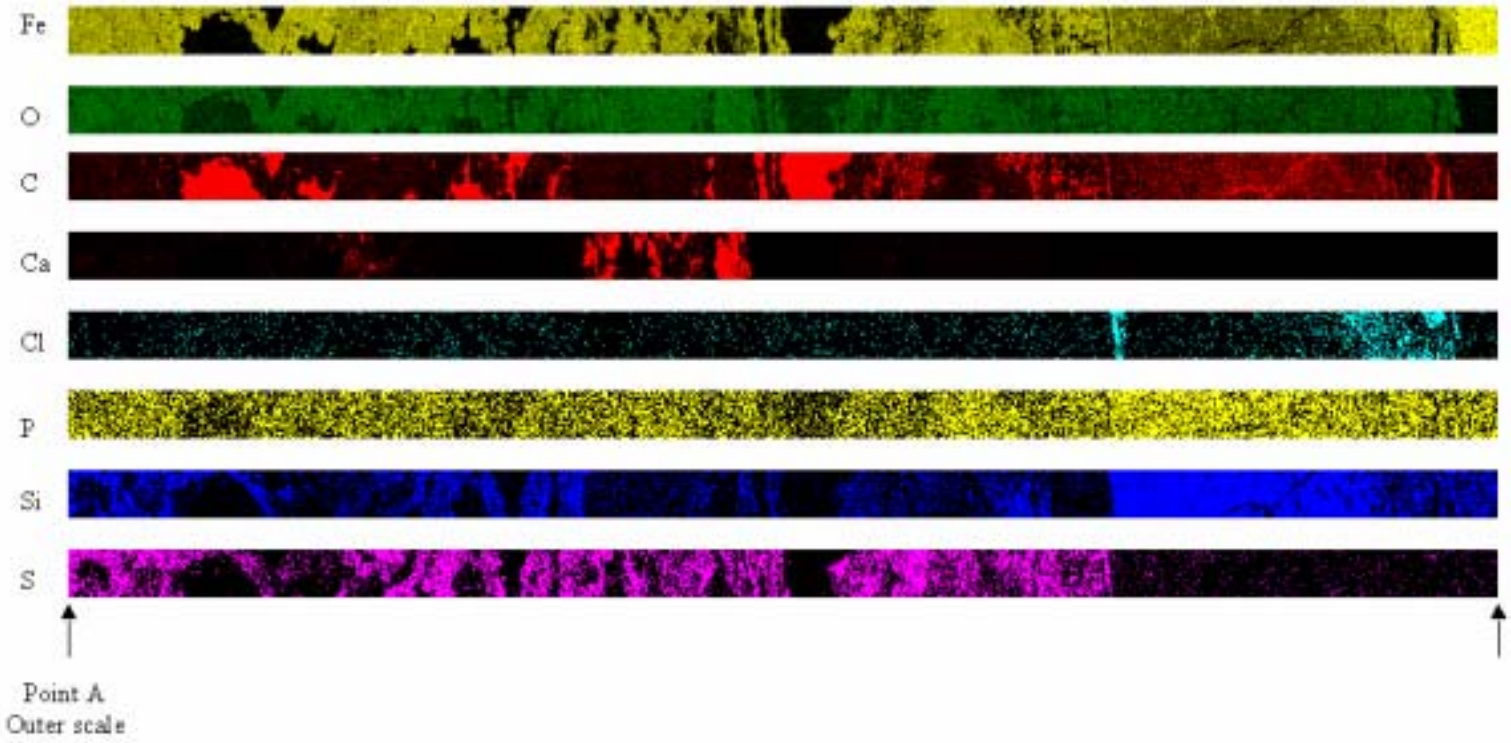


Figure 7. Elemental mapping of cross section of sample DL00046 by electron microprobe (240X).

Corrosion is Different from Iron Release

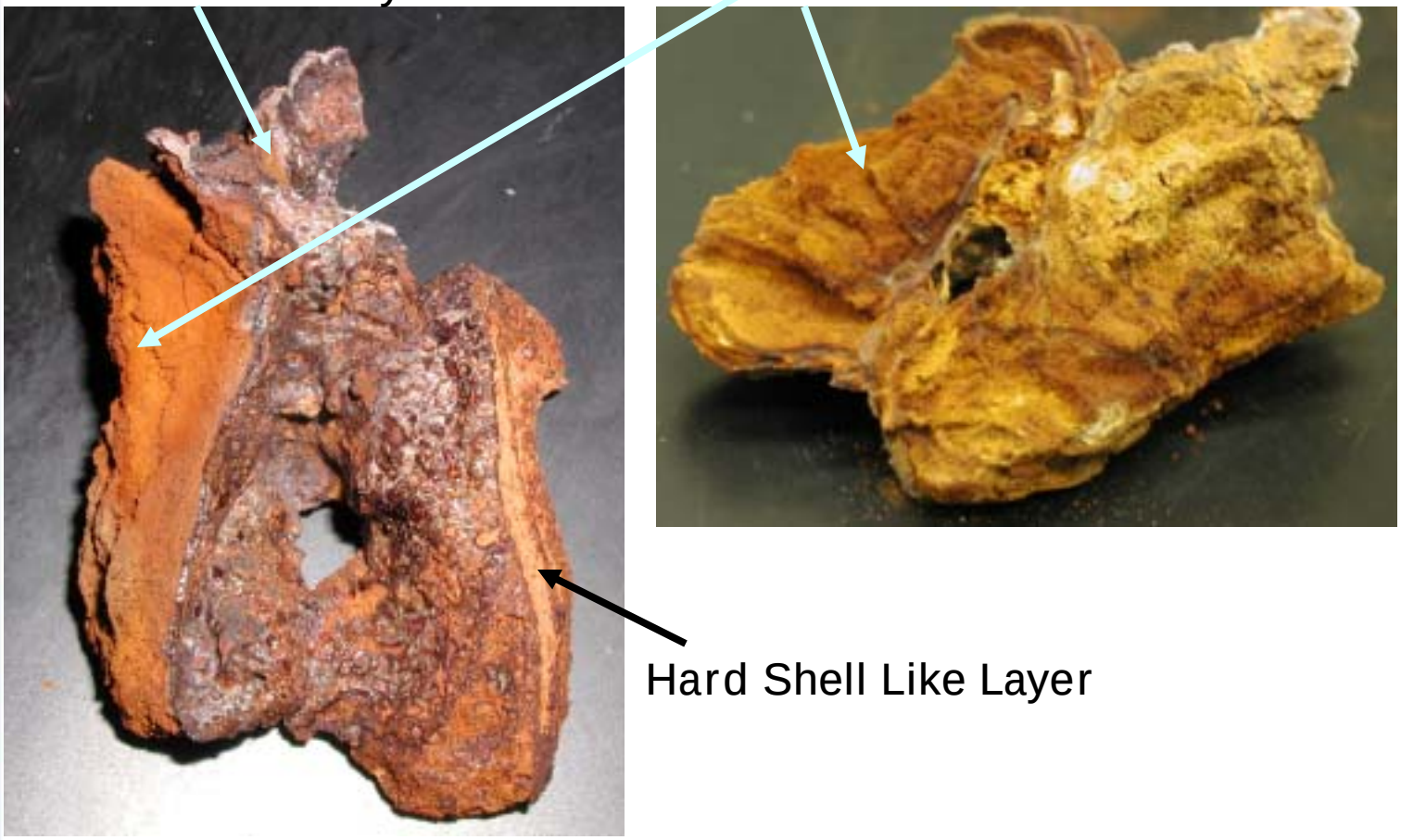
Corrosion of iron is the conversion of "metallic iron" to an oxidized form, either soluble or an oxidized scale.

- $Fe \rightarrow Fe^{2+} + 2e^-$
- Usually measured as weight loss from metallic iron

Iron release is the transport of iron, in soluble form or as a particle, from corrosion scale or metal to bulk water.

- Cumulative effect of corrosion, hydraulic scouring and dissolution of corrosion scales.
- Usually measured as concentration of iron in bulk water

Tubercle Structure



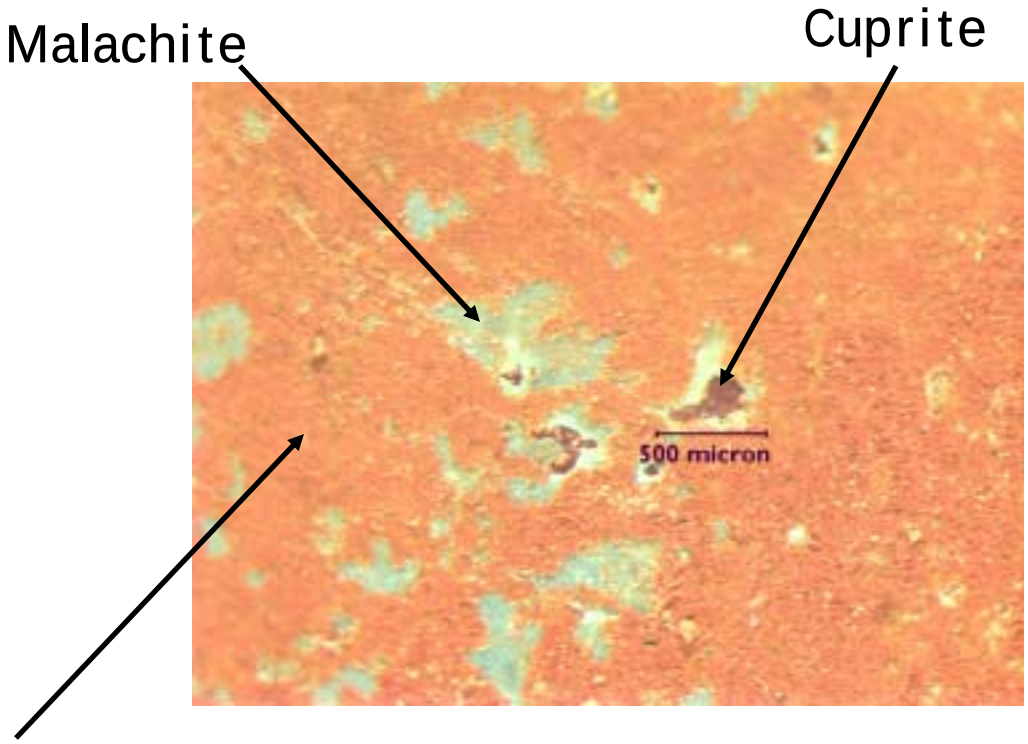
Tubercle Structure

Key Iron Release Model Features

Role of Particles/Colloids

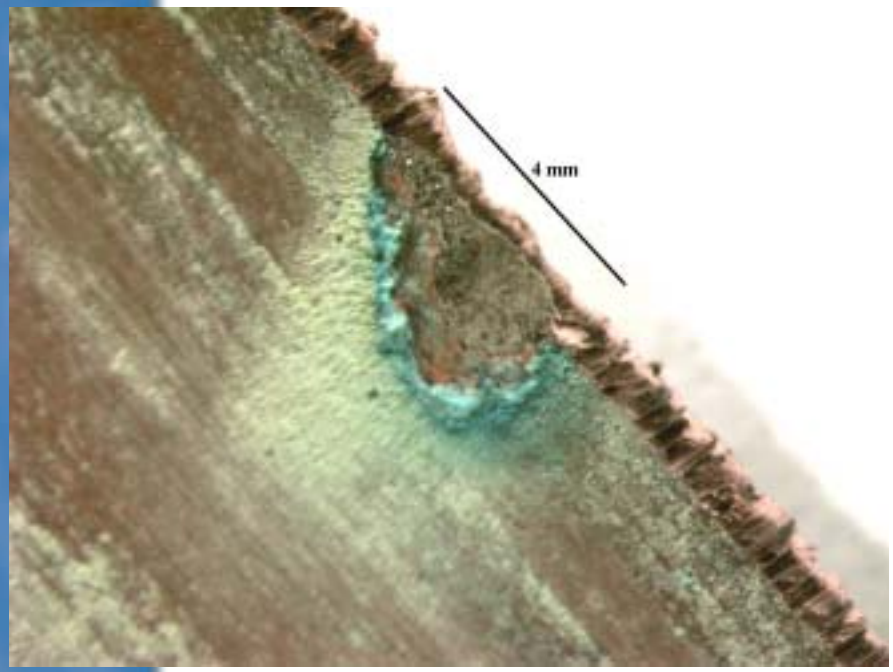
- When oxygen and chlorine are in contact with scale, ferrous ions are oxidized within the scale or close to the surface- *the iron is incorporated into the scale*
- When oxidants are not present at the surface, ferrous iron can diffuse into solution and is oxidized there- *particles form in the water*

Corrosion of Copper Pipes

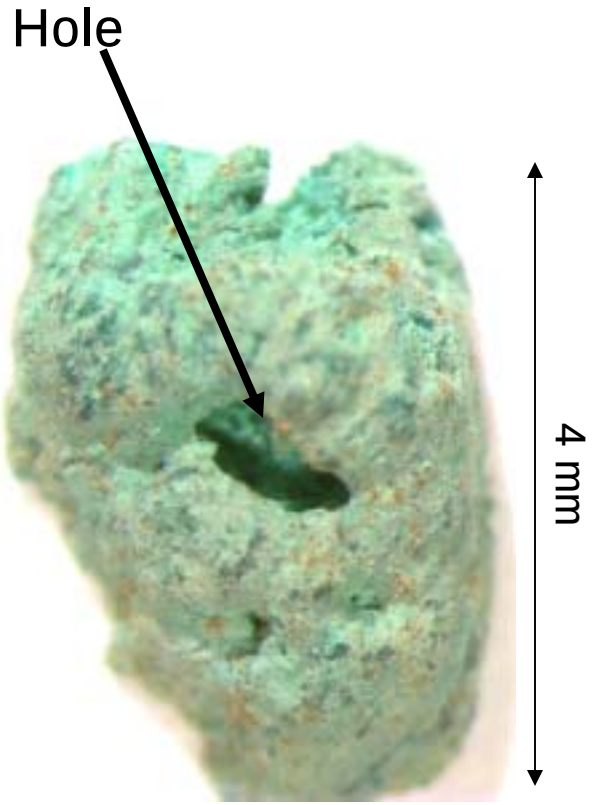


Copper Pitting

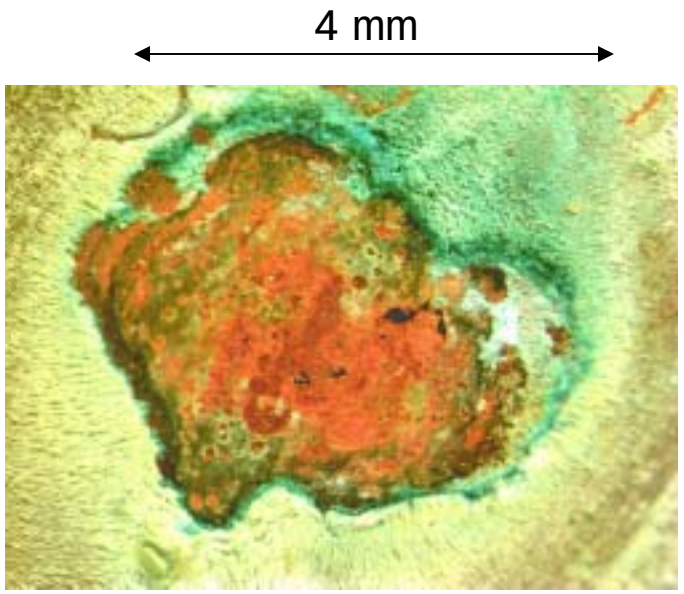
Insert Cu pipe photo here



Copper Pitting



Copper Corrosion Deposit



Pit Beneath Corrosion Deposit

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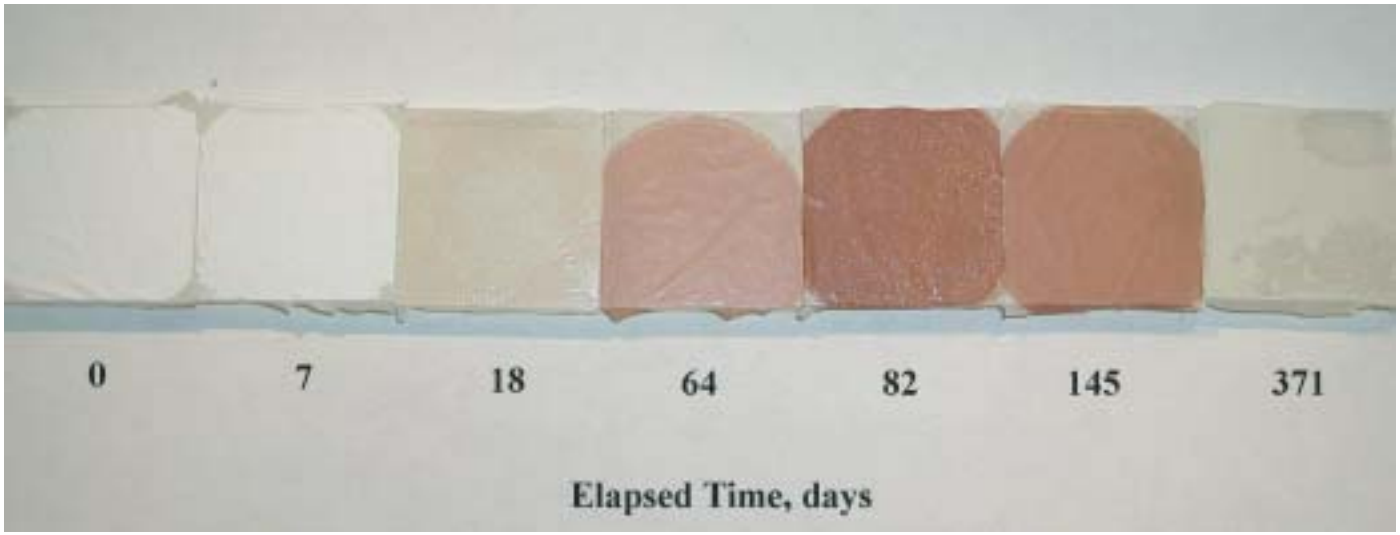
Lead Aging



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Lead Aging

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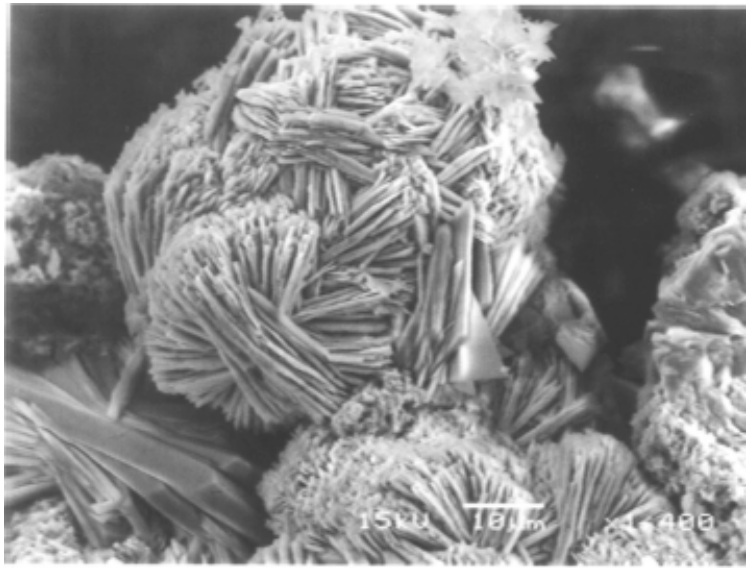
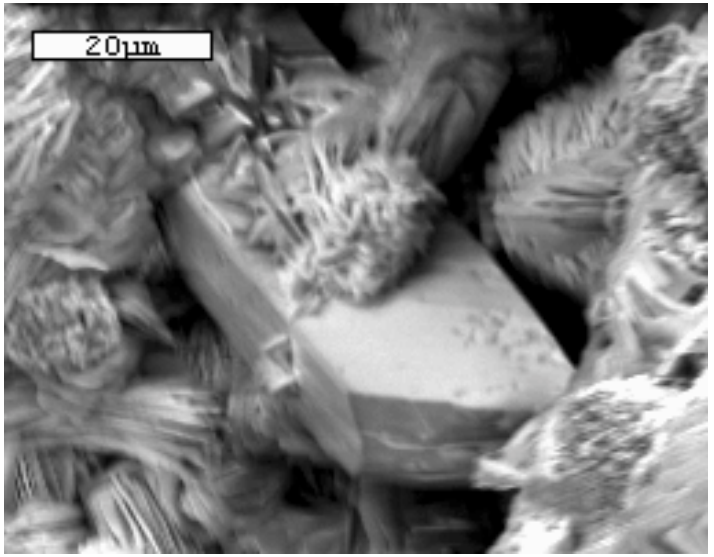


Goethite



Phosphate Crystal in Goethite